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Iris Analysis for Biometric Recognition Systems

Springer

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To all our
Teachers, from KG to PG,
and
All Students, past and present, who are
always behind our crafted achievements!!!

—Rajesh M. Bodade and Sanjay N. Talbar

Foreword

It is a pleasure to be invited to write a preface for this book, *Iris Analysis for Biometric Recognition Systems*, by R. M. Bodade and S. N. Talbar. The human iris is well known as a stable and reliable biometric, and iris recognition is a fairly well-developed area of research now, with a few books already available on the subject. Then, what is new about this book?

The book provides a comprehensive overview of the developments in this important area of biometrics, in addition to describing some related work of the authors in the use of the complex wavelet transform.

The book has examined in detail different aspects of iris analysis, where the authors review the state of the art in the field, and present their own recent work in the area. Chapter 1 gives a nice introduction to the area. Chapter 2 presents an overview of the related research in the area. This chapter covers areas right from iris segmentation to feature extraction and recognition. It can serve as a starting point for a beginner in the area. Chapter 3 presents two simple, yet elegant, iris segmentation methods. As in some popular computer vision applications, the authors use heuristics backed by empirical studies and statistical verification. The pupil dynamics method also leads to an iris aliveness detection method.

Wavelets are not new. The use of the Dual Tree Complex Wavelet Transform (DT-CWT, hereafter), however, presents new avenues in feature extraction, which help ameliorate limitations of the traditional Discrete Wavelet Transform. The heart of the authors' recognition scheme is built around this form of wavelet transform. Texture-based features have traditionally been used for iris analysis. The authors show the use of the DT-CWT and Rotated Complex Wavelet Filters (RCWF) at different orientations and scales, at low computational cost, and provide results of extensive experimentation on standard databases in support of the proposed methodology.

The authors have created a fairly comprehensive reference for beginners and practitioners alike, in iris recognition. An important aspect of the book is its ability to explain the physical significance of many concepts in a lucid manner, which is important for an engineering practitioner, without getting lost in mathematical details. At the same time, the text provides enough pointers to a mathematically oriented reader to delve further into the myriad depths of the subject.

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Preface

Reliable personal biometric recognition is of paramount importance to modern societies, essentially due to increased use of e-commerce on one hand and rise in illegal and terrorist acts on the other hand. In this context, among other biometric traits, the iris is commonly accepted as one of the most unique and stable biometric traits and it has been successfully applied at airports and at advanced ATMs. Iris is the annular part of an eye surrounded by other unwanted parts. Therefore, fast and accurate iris segmentation and unique feature extraction are the most essential aspects of iris recognition system to achieve error-free recognition in real-time. At the same time, iris recognition system is required to be robust against counterfeit attacks.

In this book, we addressed these issues in two iris segmentation methods, one is fast and customized iris segmentation method and the other is focused on accurate methods based on pupil dynamics. Dual Tree Complex Wavelet Transform (DT-CWT) and Rotated Complex Wavelet Filters (RCWF) have been described to extract the randomly oriented multidirectional features.

Existing iris segmentation methods are either time-consuming or inaccurate and are tested on the manually edited nonrealistic CASIA database. These methods fail in segmentation of realistic images of UBIRIS database, which has been addressed in the first method using Canny operator and tangents without employing Hough transform for computational efficiency.

Most of the iris segmentation methods assume boundaries of iris as circle or ellipse, which is seldom true but exact iris is of slightly irregular shape. In the second method, we have segmented an iris of exact shape without any loss of iris data accurately by exploring the pupil dynamics of human eye. The pupil dynamics is a property of the real eye and it is also used for fake iris detection. This method has not only provided extremely high segmentation accuracy but also the excellent recognition rate, due to the loss-free, accurately segmented iris images. This novel method of iris segmentation is also inherently capable of fake iris detection.

In this book, the theories of wavelet transform and complex wavelet transform have been covered in brief. Designs of Wavelet filters, Dual Tree Complex Wavelet Transform filters, and Rotated Wavelet Filters have also been presented. These filters are used to extract randomly oriented, multidirectional texture features of an iris. We used DT-CWT and RCWF jointly to extract unique features of iris in 12 different

orientations. This method successfully addressed the issue of higher computational cost of Gabor filter on one hand and inferior recognition performance of standard DWT, due to its limited directionality, on the other hand.

Thus, in this research work we designed accurate and time-efficient algorithms for all subsystems of robust iris recognition system, i.e., fake iris detection, iris segmentation, feature extraction, and matching which have been presented in five chapters. A comprehensive literature survey of existing iris recognition techniques is presented in Chap. 2. Iris segmentation methods are proposed in Chap. 3. Fast iris segmentation method customized for UBIRIS database and accurate iris segmentation algorithm using pupil dynamics are presented in this chapter. The strengths and weaknesses of our method compared to existing methods are also brought out. The inherent anti-spoofing mechanism of pupil dynamics-based iris segmentation method is outlined in this chapter. The analysis of iris texture brings out the challenges in feature extraction for iris recognition. The essence of wavelets, complex wavelets, and rotated wavelets have been explained in Chap. 4. The design of filters for complex wavelet transform and design of rotated complex wavelet filter for feature extraction are presented in this chapter. Finally, the conclusion and directions for future work are outlined in Chap. 5.

We hope this book will prove to be useful for all readers and will give future direction for postgraduate students and researchers in the area of Image Processing and Pattern Recognition. In spite of our great care, it is likely that some errors might have crept into the text. We appreciate any corrections and suggestions, which will help in the improvement of the book.

Happy reading and warm regards!!!

Indore, India Rajesh M. Bodade
Nanded, India Sanjay N. Talbar

Acknowledgments

It is a matter of great pride for me to have been associated with Prof. Sanjay N. Talbar, first as his research scholar and then as a coauthor of this book. It is with great pleasure that I express my deep sense of gratitude to him for his valuable guidance, constant encouragement and motivation, and support throughout this work. He has not only shaped my career as a passionate teacher, but also inspired me to write this book.

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Rajesh M. Bodade

Contents

Acronyms

1-D	One Dimensional
2-D	Two Dimensional
CoWT	Continuous (Analog) Wavelet Transform
CWT	Complex Wavelet Transform
DFT	Discrete Fourier Transform
DT-DWT	Dual Tree Discrete Wavelet Transform
DT-DWT(K)	Kingsbury's Dual Tree Discrete Wavelet Transform
DT-DWT(S)	Selesnick's Dual Tree Discrete Wavelet Transform
DWT	Discrete Wavelet Transform
FFT	Fast Fourier Transform
FIR	Finite Impulse Response
FT	Fourier Transform
MRA	Multi-Resolution Analysis
PR	Perfect Reconstruction
STFT	Short-Time Fourier Transform
SWT	Stationary Wavelet Transform
WP	Wavelet Packet Transform
WT	Wavelet Transform
σ	Standard Deviation

About the Authors

Rajesh M. Bodade is currently working as an Associate Professor in Faculty of Communication Engineering (FCE), Military College of Telecommunication Engineering, Mhow, Indore, India. He completed his Ph.D. in Electronics and Telecommunication Engineering (Iris Analysis for Biometric Recognition System) from SRTM University, Nanded, India in 2011. Dr. Bodade has more than 20 years of teaching experience. He received "Chief of Army Staff Medal and Commendation" and "General Officer Command in Chief-Army Training Command Medal and Commendation" on 26 January 2011 and 15 August 2013, respectively, for his outstanding contribution in teaching and research work at MCTE, Mhow. He has published 20+ papers in refereed Journals and National/ International Conferences of repute. He is Life member of Indian Society for Technical Education, Institution of Engineers (India) and Fellow of IETE. His research interests include signal processing, pattern recognition, biometrics, SDR, and cognitive radio.

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